BAYOU DE LOUTRE TMDL FOR DISSOLVED OXYGEN

May 28, 2002

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FOR DISSOLVED OXYGEN

SUBSEGMENT 080501

Prepared for

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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that are not meeting water quality standards and to develop total maximum daily pollutant loads for those waterbodies. A total maximum daily load (TMDL) is the amount of pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be distributed or allocated to point sources and nonpoint sources (NPS) discharging to the waterbody. This report presents a TMDL that has been developed for dissolved oxygen (DO) for Bayou de Loutre (subsegment 080501) in the Ouachita River basin in northern Louisiana.

Bayou de Loutre is located northeast of Farmerville, LA in the Ouachita River basin. The Arkansas State line forms the northern boundary of the subsegment. This subsegment receives drainage from more than 126 mi^2 of upstream area in Arkansas and has a total drainage area (from both states) of 430 mi^2. The main stem of Bayou de Loutre extends approximately 51 miles from the Arkansas State line downstream to its confluence with the Ouachita River. Most of the Bayou de Loutre subsegment is forested and sparsely populated with minimal agricultural use.

Subsegment 080501 was listed on the Modified Court Ordered 303(d) List for Louisiana as not fully supporting the designated use of propagation of fish and wildlife and was ranked as priority #2 for TMDL development. The causes for impairment cited in the 303(d) List included organic enrichment/low DO. The water quality standard for DO in this subsegment is 5 mg/L year round.

A water quality model (LA-QUAL) was set up to simulate DO, carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen, and organic nitrogen in the subsegment. The model was set up and calibrated using LDEQ assessment data collected from 1958 through 1999 and 1991 through 1998, and other various information obtained from LDEQ, Arkansas Department of Environmental Quality (ADEQ), and US Geological Survey (USGS). There were no intensive survey data available for this subsegment. The projection simulation was run at critical flows and temperatures to address seasonality as required by the Clean Water Act. Reductions of existing NPS loads were required for the projection simulation to show the DO standard of 5 mg/L being maintained. In general, the modeling in this study was consistent with guidance in the Louisiana TMDL Technical Procedures Manual.

A TMDL for oxygen demanding substances (CBOD, ammonia nitrogen, organic nitrogen, and sediment oxygen demand (SOD)) was calculated using the results of the projection simulation. Both implicit and explicit margins of safety (MOS) were included in the TMDL calculations. The results of the modeling and TMDL calculations showed that NPS loads will need to be reduced by approximately 72% to meet the DO standard of 5 mg/L in subsegment 080501.

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1.0 INTRODUCTION

This report presents a total maximum daily load (TMDL) for dissolved oxygen (DO) for Bayou de Loutre, which is subsegment 080501. This subsegment was listed on the Modified Court Ordered 303(d) List for Louisiana as not fully supporting the designated use of propagation of fish and wildlife and was ranked as priority #2 for TMDL development. The suspected sources and suspected causes for impairment in the 303(d) List are included in Table 1.1. The TMDL in this report was developed in accordance with Section 303(d) of the Federal Clean Water Act and EPA's regulations at 40 CFR 130.7. The 303(d) Listings for other pollutants in this subsegment are being addressed by EPA and the Louisiana Department of Environmental Quality (LDEQ) in other documents.

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standard for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the wasteload allocation (WLA), the load allocation (LA), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern, and the LA is the load allocated to nonpoint sources (NPS). The MOS is a percentage of the TMDL that accounts for the uncertainty associated with the model assumptions, data inadequacies, and future growth.

Table 1.1. Summary of 303(d) Listing of subsegment 080501 (EPA 2000).

Subsegment Number	Waterbody Description	Suspected Sources	Suspected Causes	Priority Ranking (1 = highest)
080501	Bayou de Loutre	Unknown source	Organic Enrichment/low DO Lead Mercury Salinity/TDS/chlorides/sulfates	2

2.0 STUDY AREA DESCRIPTION

2.1 General Information

Bayou de Loutre (subsegment 080501) is located northeast of Farmerville, LA in the Ouachita River basin (see Figure A.1 in Appendix A). This subsegment receives drainage from more than 126 mi^2 of upstream area in Arkansas and has a total drainage area (from both states) of 430 mi^2 (USGS 1971). Within subsegment 080501, the main stem of Bayou de Loutre extends approximately 51 miles from the Arkansas State Line downstream to the confluence of Bayou de Loutre and the Ouachita River (see Figure A.2 in Appendix A). As shown in Table 2.1, the primary land use in the Bayou de Loutre subsegment is forestland.

Table 2.1. Land uses in subsegment 080501 based on GAP data (USGS 1998).

Land Use Type	% of Total Area
Fresh Marsh	0.0%
Saline Marsh	0.0%
Wetland Forest	14.7%
Upland Forest	57.5%
Wetland Scrub/Shrub	0.1%
Upland Scrub/Shrub	17.8%
Agricultural	7.1%
Urban	0.1%
Water	2.6%
Barren Land	0.0%
TOTAL	100.0%

2.2 Water Quality Standards

The numeric water quality standards and designated uses for this subsegment are shown in Table 2.2. Bayou de Loutre is designated as an outstanding natural resource water in Louisiana. The primary numeric standard for the TMDL presented in this report is the DO standard of 5 mg/L year round.

Table 2.2. Water quality standards and designated uses (LDEQ 2000).

Subsegment Number	080501
Waterbody Description	Bayou de Loutre - Arkansas State Line to Ouachita River
Designated Uses	ABCG
Criteria:	
Chloride	250 mg/L
Sulfate	45 mg/L
DO	5 mg/L (year round)
pH	6.0-8.5
Temperature	33 °C
TDS	500 mg/L

USES: A – primary contact recreation; B – secondary contact recreation; C – propagation of fish and wildlife; D – drinking water supply; E – oyster propagation; F – agriculture; G – outstanding natural resource water; L – limited aquatic life and wildlife use.

2.3 Identification of Sources

2.3.1 Point Sources

A listing of all NPDES permits in the Ouachita and Calcasieu River basins was searched to identify any permits within the Bayou de Loutre subsegment (080501). This listing was prepared by EPA Region 6 using databases and permit files from LDEQ. Based on this listing, one NPDES permit was identified within subsegment 080501. It was included in the model and TMDL calculations for this subsegment. The approximate location of this discharge is shown on Figure A.2 in Appendix A. Other relevant information for this discharge is listed below:

	Town of Marion Sewage Treatment Plant (STP)
Permit number:	LA0043656
Receiving stream:	Big Creek to Bayou de Loutre
Flow:	0.26 MGD
Permit limits:	10 mg/L $CBOD_5$ and 5 mg/L ammonia nitrogen

2.3 Nonpoint Sources

The 303(d) Listing for the Bayou de Loutre subsegment did not include any specific nonpoint sources (Table 1.1). The 303(d) Listings for two adjacent subsegments with similar land uses (080609 - Corney Bayou and 080605 - Bayou D'Arbonne) were examined to try to gain insight for the Bayou de Loutre subsegment, but the suspected sources for those two subsegments were “unknown source” and “natural sources”.

2.4 Previous Data and Studies

Listed below are previous water quality data and studies in or near the Bayou de Loutre subsegment. The locations of the LDEQ and Arkansas Department of Environmental Quality (ADEQ) monitoring stations are shown on Figure A.2 in Appendix A.

1. Monthly data collected by LDEQ for “Bayou de Loutre near Monroe, LA” (Station 0072) for June 1958 to December 1999.
2. Monthly data collected by LDEQ for “Bayou de Loutre near Farmerville, LA” (Station 0324) for January 1991 to May 1998.
3. Data collected by ADEQ for “Cornie Bayou near Three Creeks” (Station OUA02) for 1968 to present.
4. Data collected by ADEQ for “Bayou de Loutre near El Dorado, Arkansas” (Station OUA05) for 1960 to present.
5. Field data were collected on January 29, 1980 at 11 sites along Bayou de Loutre between the Arkansas State Line and the mouth of Bayou de Loutre. Parameters that were measured included temperature, DO, BOD_5, BOD_{20}, total Kjeldahl nitrogen (TKN), ammonia nitrogen, nitrate+nitrite nitrogen, and phosphorus.

3.0 CALIBRATION OF WATER QUALITY MODEL

3.1 Model Setup

In order to evaluate the linkage between pollutant sources and water quality, a computer simulation model was used. The model used for these TMDLs was LA-QUAL (version 4.13), which was selected because it includes the relevant physical, chemical, and biological processes and it has been used successfully in the past for other TMDLs in Louisiana. The LA-QUAL model was set up to simulate organic nitrogen, ammonia nitrogen, ultimate carbonaceous biochemical oxygen demand (CBODu), and DO.

The main stem of Bayou de Loutre was divided into five reaches to represent varying depths and widths along the stream (see Figure A.3 in Appendix A). In order to include the Town of Marion STP in the model, a branch was added with one more reach to simulate Big Creek from the Marion STP to the main stem of Bayou de Loutre. All of the reaches were divided into smaller elements to simulate any variations in water quality within each reach.

3.2 Calibration Period and Calibration Targets

An intensive field survey was not performed for the study area due to schedule and budget limitations. A synoptic survey of the study area was performed by FTN in August 2001, but only limited data were collected during that survey (see Appendix B). The historical period for which water quality data were collected for both LDEQ stations within the subsegment was January 1991 through May 1998 (see Section 2.4).

Water quality data were retrieved from the LDEQ website. These data are shown in Appendix B. The two conditions that usually characterize critical periods for DO are high temperatures and low flows. High temperatures decrease DO saturation values and increase rates for oxygen demanding processes (BOD decay, nitrification, and sediment oxygen demand (SOD)). In most systems, low flows cause reaeration rates to be lower. The purpose of selecting a critical period for calibration is so that the model will be calibrated as accurately as possible for making projection simulations for critical conditions.

Based on the LDEQ data in Appendix B, the calibration period was selected as July 15 to September 9, 1997. This period represented the most critical period for DO. The calibration targets (i.e., the concentration to which the model was calibrated) for each parameter were set to the averages of the concentrations measured during the calibration period. Because the LDEQ routine monitoring data did not include CBOD or ammonia nitrogen, the calibration targets for those parameters were estimated based on measured concentrations of total organic carbon (TOC) and TKN.

The calibration targets for CBODu were estimated from the TOC data based on statistics from LDEQ's long term BOD analyses. The LDEQ’s long term BOD analyses consisted of 140 samples from intensive surveys in the Ouachita River basin during 2001. These samples were analyzed for numerous parameters including CBODu and TOC. The ratio of CBODu to TOC was calculated for each sample and the median of those 140 ratios was determined to be 1.10. Using this result, the CBODu calibration targets were estimated as 1.10 times the average TOC during the calibration period. Data from the LDEQ long term BOD analyses are shown in Appendix C.

The calibration targets for ammonia nitrogen were estimated from the TKN data based on statistics from the ammonia nitrogen and TKN data collected by LDEQ for Bayou de Loutre near Monroe (0072). The only ammonia nitrogen data collected by LDEQ for this subsegment was monthly data during 1999 at station 0072. The ratio of ammonia nitrogen to TKN was calculated for each sample and the median of those ratios was determined to be 0.12. Using this result, the ammonia nitrogen calibration targets were estimated as 0.12 times the average TKN during the calibration period. The data used to calculate the ammonia to TKN ratios are included in Appendix B.

3.3 Temperature Correction of Kinetics (Data Type 4)

The temperature correction factors used in the model were consistent with the Louisiana Technical Procedures Manual (the “LTP”; LDEQ 2001). These correction factors were:

- Correction for BOD decay: 1.047 (value in LTP is same as model default)

• Correction for SOD:	1.065 (value in LTP is same as model default)
• Correction for ammonia N decay:	1.070 (specified in Data Group 4)
• Correction for organic N decay:	1.020 (not specified in LTP; model default used)
• Correction for reaeration:	automatically calculated by the model

3.4 Hydraulics (Data Type 9)

The hydraulics were specified in the input for the LA-QUAL model using the power functions (width = a * Q^b + c and depth = d * Q^e + f). For the main stem of Bayou de Loutre, widths and depths were based on measurements from the 2001 FTN synoptic survey, which was conducted during a low flow period similar to the calibration period. The FTN synoptic survey included cross sections at only two sites in the Bayou de Loutre subsegment (LDEQ stations 0324 and 0072). The measured depth and width for station 0324 were assigned to reach 1 and the measured depth and width for station 0072 were assigned to reach 6. The widths and depths were then varied linearly from reach to reach along the main stem.

For Big Creek (reach 4), the depth and width were set to the average values from two LDEQ reference stream sites on Meridian Creek. The LDEQ data for Meridian Creek are shown in Appendix D. The model inputs for the calibration are summarized in Appendix E.

3.5 Initial Conditions (Data Type 11)

Because temperature is not being simulated in the model, the temperature for each reach was specified in the initial conditions for LA-QUAL. The temperatures for LDEQ stations 0324 and 0072 were averaged for the calibration period and then those averages were combined to yield an overall average temperature of 27.4°C that was used as the temperature for all reaches in the model. The input data and sources are shown in Appendix E.

For constituents not being simulated, the initial concentrations were set to zero; otherwise, the model would have assumed a fixed concentration of those constituents and the model would have included the effects of the unmodeled constituents on the modeled constituents (e.g., the effects of algae on DO).

3.6 Water Quality Kinetics (Data Types 12 and 13)

Kinetic rates used in LA-QUAL include reaeration rates, CBOD decay rates, nitrification rates, and mineralization rates (organic nitrogen decay). The values used in the model input are shown in Appendix E.

For reaeration, the Louisiana Equation (option 15) was specified in the model because it was developed specifically for streams in Louisiana and it has been used successfully in the past for other TMDLs in Louisiana.

The rates for CBOD decay and nitrification (ammonia nitrogen "decay") were based on median values of laboratory decay rates from LDEQ's long term BOD analyses. The LDEQ long term BOD analyses consisted of 140 samples from intensive surveys in the Ouachita River basin during 2001. The median decay rates for CBOD and nitrogenous biochemical oxygen demand (NBOD) were approximately 0.06/day and 0.07/day, respectively. These data are shown in Appendix C. Because instream decay rates are typically slightly higher than laboratory decay rates, both the CBOD decay rates and the nitrification rates were set to 0.10/day for all reaches.

The mineralization rates (organic nitrogen decay) in the model were set to 0.02/day for all reaches. This value was similar to the values shown in Table 5.3 of the "Rates, Constants, and Kinetics" publication (EPA 1985) for dissolved organic nitrogen being transformed to ammonia nitrogen. The literature values for mineralization rates are shown in Appendix F.

One other input value was specified for characterizing the nitrification process. In the program constants section of the model input file (data type 3), the nitrification inhibition option was set to 1 instead of the default of option number 2. With the default option, the nitrification rate drops rapidly when the DO drops below 2 mg/L, which results in an unrealistic build up of ammonia nitrogen at low DO. Option number 1 provides nitrification inhibition that is similar to what is simulated in other widely used water quality models such as QUAL2E and WASP (see Figure 3.5 in FTN 2000).

3.7 Nonpoint Source Loads (Data Type 19)

The NPS loads that are specified in the model can be most easily understood as resuspended load from the bottom sediments and are modeled as SOD, benthic ammonia source rates, CBODu loads, and organic nitrogen loads. The SOD (specified in data type 12), the benthic ammonia source rates (specified in data type 13), and the mass loads of organic nitrogen and CBODu (specified in data type 19) were all treated as calibration parameters; their values were adjusted until the model output was similar to the calibration target values.

These four calibration parameters were adjusted in a specific order based on the interactions between state variables in the model. First, the organic nitrogen loads were adjusted until the predicted organic nitrogen concentrations were similar to the observed concentrations. Organic nitrogen was calibrated first because none of the other state variables will affect the organic nitrogen concentrations. Next, the benthic ammonia source rates were adjusted until the predicted ammonia nitrogen concentrations were similar to the observed concentrations. Then the CBODu loads were adjusted until the predicted CBODu concentrations were similar to the observed concentrations. Finally, the SOD rates were adjusted until the predicted DO concentrations were similar to the observed concentrations. The DO was calibrated last because all of the other state variables affect DO.

3.8 Headwater and Incremental Flow Rates (Data Types 15 and 19)

The inflows were calculated from USGS flow data for the Dugdemona River at Jonesboro (USGS 07371500) (see Appendix G). The average flow during the calibration period was divided by the gage drainage area to give a flow per unit area of 0.067 cfs/mi^2. This was then multiplied by the drainage area of Bayou de Loutre in Arkansas (126.46 mi^2) to give a headwater flow rate of 8.47 cfs (0.240 m^3/sec). The flow for Big Creek was calculated by multiplying the drainage area of Big Creek (~4 mi^2) times the flow per unit area from Dugdemona to obtain a flow of .27 cfs (.008 cms).

Since the flow into Bayou de Loutre could not be accurately approximated by modeling a few large tributaries, incremental flow was chosen. An incremental flow was calculated by multiplying the flow per unit area from the Dugdemona USGS flow gage by the area of the Bayou de Loutre watershed in the state of Louisiana. This flow, minus the flow of Big Creek, was divided by the length of the river (81.5 km) to get a flow per kilometer which was multiplied by the length of each reach to get the incremental flow per reach.

3.9 Headwater and Incremental Water Quality (Data Types 16 and 20)

The temperature and concentrations of DO, CBODu, organic nitrogen, and ammonia nitrogen were specified in the model for the headwater and the incremental flow. Inflow temperatures were set to the same value used for the initial conditions (Section 3.5). Water quality for the headwater (which also included nitrate plus nitrite) was set to the average concentrations measured at ADEQ station OUA05 during the calibration period. The data at station OUA02 was averaged with the data from ADEQ station OUA05 to calculate the incremental inflow water quality. Nitrite plus nitrate was set to zero since the only two stations available that had this data had dramatically different values. OUA05 had a value of 0.91 mg/L while OUA02 had a value of 0.05 mg/L. Thus, while the value from OUA05 was used (in the headwater data) the incremental flow nitrite plus nitrate concentration was set equal to zero. The TOC values in the ADEQ data set were converted to CBODu values by multiplying them by 1.10, which was the median ratio of CBODu to TOC from the LDEQ long term BOD analyses (shown in Appendix C). The values used as model input are shown in Appendix E. The TKN value was calculated from a ammonia TKN ratio. Finally the organic nitrogen concentration was the TKN value minus the ammonia concentration.

The water quality for Big Creek were based on LDEQ reference stream data for Meridian Creek which is near Big Creek and about the same size as Big Creek (see Figure A.2). The water quality for Big Creek were set to the average concentrations measured for Meridian Creek during the reference stream surveys in 1995 and 1996. Data for Meridian Creek are shown in Appendix D.

Since there were no water quality stations downstream of Marion STP, it was calibrated without the point source on it. It was assumed that the water quality did not vary in the reach, thus the calibration targets were placed at the end of the reach and set equal to the headwater. Any water quality concentrations not known for Meridian Creek were set equal to zero.

3.10 Point Source Inputs (Data Types 24 and 25)

One NPDES permitted discharger was include din the model. The point source flow was set to its permit design flow. The point source water quality was set based on its water quality permit limits. The point source has permit limits for $CBOD_5$ and ammonia nitrogen. The $CBOD_5$ permit limit was converted to CBODu by multiplying the $CBOD_5$:CBODu ratio from the LTP (2.3). DO was set based on the $CBOD_5$ permit limit according to guidance in the LTP (LDEQ 2001). Organic nitrogen was set to zero and nitrite+nitrate nitrogen was set to zero.

3.11 Model Results for Calibration

Plots of predicted and observed water quality for the calibration are presented in Appendix H and a printout of the LA-QUAL output file is included as Appendix I. The calibration was considered to be acceptable based on the amount of data that were available.

4.0 WATER QUALITY MODEL PROJECTION

EPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Therefore, the calibrated model was used to project water quality for critical conditions. The identification of critical conditions and the model input data used for critical conditions are discussed below.

4.1 Identification of Critical Conditions

Section 303(d) of the Federal Clean Water Act and EPA's regulations at 40 CFR 130.7 both require the consideration of seasonal variation of conditions affecting the constituent of concern and the inclusion of a MOS in the development of a TMDL. For the TMDL in this report, analyses of LDEQ long-term ambient data were used to determine critical seasonal conditions. A combination of implicit and explicit MOS was used in developing the projection model.

Critical conditions for DO have been determined for Louisiana streams in previous TMDL studies. The analyses concluded that the critical conditions for stream DO concentrations occur during periods with negligible nonpoint runoff, low stream flow, and high stream temperature.

When the rainfall runoff (and nonpoint loading) and stream flow are high, turbulence is higher due to the higher flow and the stream temperature is lowered by the cooler precipitation and runoff. In addition, runoff coefficients are higher in cooler weather due to reduced evaporation and evapotranspiration, so that the high flow periods of the year tend to be the cooler periods. DO saturation values are, of course, much higher when water temperatures are cooler, but BOD decay rates are much lower. For these reasons, periods of high loading are periods of higher reaeration and DO but not necessarily periods of high BOD decay.

LDEQ interprets this phenomenon in its TMDL modeling by assuming that the annual nonpoint loading, rather than loading for any particular day, is responsible for the accumulated benthic blanket of the stream, which is, in turn, expressed as SOD and/or resuspended BOD in the model. This accumulated loading has its greatest impact on the stream during periods of higher temperature and lower flow.

According to the LTP, critical summer conditions in DO TMDL projection modeling are simulated by using the annual 7Q10 flow or 0.1 cfs, whichever is higher, for all headwaters, and 90th percentile temperature for the summer season. Model loading is from perennial tributaries, SOD, and resuspension of sediments.

In reality, the highest temperatures occur in July-August and the lowest stream flows occur in October-November. The combination of these conditions plus the impact of other conservative assumptions regarding rates and loadings yields an implicit MOS that is not quantified. Over and above this implicit MOS, an explicit MOS of 10% for NPS was incorporated into the TMDL in this report to account for model uncertainty.

4.2 Temperature Inputs

The LTP (LDEQ 2001) specified that the critical temperature should be determined by calculating the 90th percentile seasonal temperature for the waterbody being modeled. Because the LDEQ 0324 station for Bayou de Loutre has only approximately 9 years of data, LDEQ data for another subsegment were used for this analysis. Long term temperature data from Bayou de Loutre near Monroe, Louisiana (LDEQ station 0072) were used to calculate a 90^{th} percentile summer temperature of 29.0EC. This was used in the temperature inputs in the entire model. This value is specified in Data Type 11 in the model and is shown in Appendix J. The 90^{th} percentile temperature calculations are shown in Appendix K.

Because Bayou de Loutre has a year round standard for DO, a winter projection simulation was not performed. As discussed above, the most critical time of year for meeting a constant DO standard is the period of high temperatures and low flows (i.e., summer).

4.3 Headwater and Tributary Inputs

The inputs for the headwaters and tributaries for the projection simulation were based on guidance in the LTP. As specified in the LTP, the DO concentration for the headwater and tributary inflows was set to 90% saturation at the critical temperature. Headwater and tributary concentrations for other parameters were kept at the calibration values.

The published 7Q10 flow for Bayou de Loutre near Laran, LA is 3.0 cfs (USGS 07364700). This 7Q10 flow was divided by the drainage are to get a 7Q10 flow per unit area (0.0213 cfs/mi^2). This flow per unit area was multiplied by the drainage area in Arkansas (just as in the calibration model) to get a headwater flow of 2.69 cfs for Bayou de Loutre. The LTP specifies that the critical flow rate for summer should be set to the 7Q10 flow or 0.1 cfs, whichever is higher. Therefore, the headwater flow rate in the projection simulation was set to 2.69 cfs. The published 7Q10 information is shown in Appendix L.

For Big Creek, a rough estimate of the drainage area was made from the 1:100,000 USGS quadrangle map. The published 7Q10 flow for Dugdemona River at Jonesboro (USGS 07371500) was 1.8 cfs. This 7Q10 was divided by the drainage area for the gage to get the 7Q10 flow per unit area (0.00507 cfs/mi^2). This 7Q10 flow per unit area was multiplied by the drainage area of Big Creek (~4 mi^2) to determine a 7Q10 flow of 0.02 cfs which was less than 0.1 cfs. So the headwater flow was set to 0.1 cfs (0.003 cms).

4.4 Point Source Inputs

The only change made to the point source inputs from the calibration was to increase the flow. The point source flow for the projection simulation was set to 1.25 times the design flow to allow for an MOS.

4.5 Nonpoint Source Loads

Because the initial projection simulation showed low DO values, the NPS loadings were reduced until all of the predicted DO values were equal to or greater than the water quality standard of 5.0 mg/L. The same percent reduction was applied to all components of the NPS loads (SOD, benthic ammonia source rates, and mass loads of CBODu and ammonia nitrogen). The values used as model input in the projection simulation are shown in Appendix J.

4.6 Other Inputs

The only model inputs that were changed from the calibration to the projection simulation were the inputs discussed above in Sections 4.2 through 4.6. Other model inputs (e.g., hydraulic and dispersion coefficients, decay rates, reaeration equations, etc.) were unchanged from the calibration simulation.

4.7 Model Results for Projection

A plot of predicted DO for the projection is presented in Appendix M and a printout of the LA-QUAL output file is included as Appendix N.

A NPS load reduction of approximately 72% was required to bring the predicted DO values to at least 5.0 mg/L. This percentage reduction for NPS loads represents a percentage of the entire NPS loading, not a percentage of the manmade NPS loading. The NPS loads in this report were not divided between natural and manmade because it would be difficult to estimate natural NPS loads for the study area.

No reductions are suggested for Marion STP discharge. This discharge has very little impact on Bayou de Loutre water quality.

5.0 TMDL CALCULATIONS

5.1 DO TMDL

A total maximum daily load (TMDL) for DO has been calculated for the Bayou de Loutre subsegment based on the results of the projection simulation. The DO TMDL is presented as oxygen demand from CBODu, organic nitrogen, ammonia nitrogen, and SOD. A summary of the loads for Bayou de Loutre is presented in Table 5.1.

The TMDL calculations were performed using a FORTRAN program that was written by FTN personnel. This program reads two files; one is the LA-QUAL output file from the projection simulation and the other is a small file with miscellaneous information needed for the TMDL calculations (shown in Appendix O). The output from the program is shown in Appendix P and the source code for the program is shown in Appendix Q.

Table 5.1. DO TMDL for Subsegment 080501 (Bayou de Loutre).

	Oxygen demand (kg/day) from:				**Total oxygen demand (kg/day)**
	CBODu	**Organic N**	**Ammonia N**	**SOD**	
WLA for point source	22.65	0	21.32	NA	43.98
MOS for point source	5.66	0	5.33	NA	10.99
LA for all NPS	664.29	92.52	0.11	1,656.69	2,413.62
MOS for all NPS	73.81	10.28	0.01	184.08	268.18
Total maximum daily load	766.41	102.8	26.76	1,840.77	2,736.75

The oxygen demand from organic nitrogen and ammonia nitrogen was calculated as 4.33 times the nitrogen loads (assuming that all organic nitrogen is eventually converted to ammonia). The value of 4.33 is the same ratio of oxygen demand to nitrogen that is used by the LA-QUAL model. For the SOD loads, a temperature correction factor was included in the calculations (in order to be consistent with LDEQ procedures).

5.2 Ammonia Toxicity Calculations

Although subsegment 080501 is not on a 303(d) List for ammonia, the ammonia concentrations predicted by the projection model were checked to make sure that they did not exceed EPA criteria for ammonia toxicity (EPA 1999). The EPA criteria are dependent on temperature and pH. The water temperature used to calculate the ammonia toxicity criterion for Bayou de Loutre was the same as the critical temperature used in the projection simulation (29°C). For pH, an average of the values measured at LDEQ station 0072 and 0324 during the calibration period was used. The resulting criterion was 2.7 mg/L of ammonia nitrogen. The instream ammonia nitrogen concentrations predicted for the main stem of Bayou de Loutre by the LA-QUAL model (#0.11 mg/L) were well below the criterion. This indicates that the ammonia nitrogen loadings that will maintain the DO standard are low enough that the EPA ammonia toxicity criteria will not be exceeded under critical conditions. Some of the ammonia nitrogen concentrations predicted in the upper end of Big Creek were above the criterion. This indicates that in a portion of Big Creek the ammonia nitrogen loadings that will maintain the DO standard may exceed the EPA ammonia toxicity criteria under critical conditions. The ammonia toxicity calculations are shown in Appendix R.

5.3 Summary of NPS Reductions

In summary, the projection modeling used to develop the TMDLs above showed that NPS loads need to be reduced by 72% to maintain the DO standard in Bayou de Loutre.

5.4 Seasonal Variation

As discussed in Section 4.1, critical conditions for DO in Louisiana waterbodies have been determined to be when there is negligible nonpoint runoff and low stream flow combined with high water temperatures. In addition, the model accounts for loadings that occur at higher flows by modeling sediment oxygen demand. Oxygen demanding pollutants that enter the waterbodies during higher flows settle to the bottom and then exert the greatest oxygen demand during the high temperature seasons.

5.5 Margin of Safety

The MOS accounts for any lack of knowledge or uncertainty concerning the relationship between load allocations and water quality. As discussed in Section 4.1, the highest temperatures occur in July through August and the lowest stream flows occur in October through November. The combination of these conditions, in addition to other conservative assumptions regarding rates and loadings, yields an implicit MOS which is not quantified. In addition to the implicit MOS, the TMDL in this report includes an explicit MOS of 10% for NPS loads and 20% for point source loads.

6.0 SENSITIVITY ANALYSES

All modeling studies necessarily involve uncertainty and some degree of approximation. Therefore it is of value to consider the sensitivity of the model output to changes in model coefficients, and in the hypothesized relationships among the parameters of the model. The sensitivity analyses were performed by allowing the LA-QUAL model to vary one input parameter at a time while holding all other parameters to their original value. The calibration simulation was used as the baseline for the sensitivity analysis. The percent change of the model's minimum DO projections to each parameter is presented in Table 6.1. Each parameter was varied by "30%, except for temperature, which was varied "2ºC.

Values reported in Table 6.1 are sorted by percentage variation of minimum DO from smallest percentage variation to largest. Reaeration, SOD, and depth were the parameters to which DO was most sensitive.

Table 6.1. Summary of results of sensitivity analyses.

Input Parameter	Parameter Change	Predicted minimum DO (mg/L)	Percent Change in Predicted DO (%)
Baseline	-	3.25	N/A
Reaeration	-30%	1.85	43
SOD	+30%	2.10	35
SOD	-30%	4.35	34
Reaeration	+30%	4.21	30
Depth	-30%	4.12	27
Headwater flow	-30%	2.51	23
Depth	+30%	2.53	22
Initial temperature	+2ºC	2.60	20
Initial temperature	-2ºC	3.87	19
Headwater flow	+30%	3.79	17
BOD decay rate	-30%	3.40	5
BOD decay rate	+30%	3.11	4
NH3 decay rate	+30%	3.25	<1
NH3 decay rate	-30%	3.25	<1
Organic N decay rate	+30%	3.25	<1
Organic N decay rate	-30%	3.25	<1
Wasteload DO	+30%	3.25	<1
Wasteload DO	-30%	3.25	<1
Wasteload BOD	+30%	3.25	<1
Wasteload BOD	-30%	3.25	<1
Wasteload flow	+30%	3.25	<1
Wasteload flow	-30%	3.25	<1
Wasteload NH3	+30%	3.25	<1
Wasteload NH3	-30%	3.25	<1
Wasteload organic N	+30%	3.25	<1
Wasteload organic N	-30%	3.25	<1

7.0 OTHER RELEVANT INFORMATION

This TMDL has been developed to be consistent with the antidegradation policy in the LDEQ water quality standards (LAC 33:1X.1109.A).

Although not required by this TMDL, LDEQ utilizes funds under Section 106 of the Federal Clean Water Act and under the authority of the Louisiana Environmental Quality Act to operate an established program for monitoring the quality of the state's surface waters. The LDEQ Surveillance Section collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term data base for water quality trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (Water Quality Inventory) and the 303(d) List of impaired waters. This information is also utilized in establishing priorities for the LDEQ NPS program.

The LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a five-year cycle with two targeted basins sampled each year. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the five-year cycle. Sampling is conducted on a monthly basis or more frequently if necessary to yield at least 12 samples per site each year. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, targeted basins follow the TMDL priorities. In this manner, the first TMDLs will have been implemented by the time the first priority basins will be monitored again in the second five-year cycle. This will allow the LDEQ to determine whether there has been any improvement in water quality following establishment of the TMDLs. As the monitoring results are evaluated at the end of each year, waterbodies may be added to or removed from the 303(d) List. The sampling schedule for the first five-year cycle is shown below. The Ouachita River Basin will be sampled again in 2004.

1998 – Mermentau and Vermilion-Teche River Basins
1999 – Calcasieu and Ouachita River Basins
2000 – Barataria and Terrebonne Basins
2001 – Lake Pontchartrain Basin and Pearl River Basin
2002 – Red and Sabine River Basins

(Atchafalaya and Mississippi Rivers will be sampled continuously.)

In addition to ambient water quality sampling in the priority basins, the LDEQ has increased compliance monitoring in those basins, following the same schedule. Approximately 1,000 to 1,100 permitted facilities in the priority basins were targeted for inspections. The goal set by LDEQ was to inspect all of those facilities on the list and to sample 1/3 of the minors and 1/3 of the majors.

8.0 PUBLIC PARTICIPATION

When EPA establishes a TMDL, 40 CFR §130.7(d)(2) requires EPA to publicly notice and seek comment concerning the TMDL. Pursuant to an October 1, 1999 Court Order, this TMDL was prepared under contract to EPA. After development of the draft of this TMDL, EPA commenced preparation of a notice seeking comments, information, and data from the general and affected public. Comments and additional information were submitted during the public comment period and this TMDL was revised accordingly. Responses to these comments and additional information are included in Appendix S. EPA has transmitted this revised TMDL to LDEQ for incorporation into LDEQ’s current water quality management plan.

9.0 REFERENCES

EPA. 1985. Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling (Second Edition). Written by G.L. Bowie et. al. EPA/600/3-85/040. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA.

EPA. 1999. 1999 Update of Ambient Water Quality Criteria for Ammonia. EPA-822-R-99-014. U.S. Environmental Protection Agency, Office of Water. December, 1999.

EPA. 2000. Modified Court Ordered 303(d) List for Louisiana. Downloaded from EPA Region 6 website (www.epa.gov/earth1r6/6wq/ecopro/latmdl/modifiedcourtorderedlist.xls).

FTN. 2000. Bayou Lacassine Watershed TMDL for Dissolved Oxygen. Prepared for LDEQ by FTN Associates, Ltd., Little Rock, AR: September 2000.

LDEQ. 1998. 1998 305 (b) Appendix C Table . Printed from Louisiana Department of Environment Quality website (www.deq.state.la.us/planning/305b/1998/305b-ctab.htm).

LDEQ. 2000. Environment Regulatory Code. Part IX. Water Quality Regulations. Chapter 11. Surface Water Quality Standards. § 1123. Numerical Criteria and Designated Uses. Printed from LDEQ website (www.deq.state.la.us/ planning/regs/title33/index.htm).

LDEQ. 2001. Louisiana TMDL Technical Procedures Manual. Developed by LDEQ Office of Water Resources. Revised by R.K. Duerr and M.U. Aguillard, Engineering Services Group 2, Environmental Technology Division, Louisiana Department of Environmental Quality, Baton Rouge, LA: May 22, 2001.

Lee, F.N., D. Everett, and M. Forbes. 1997. Lowflow Data for USGS Sites through 1993. Report prepared for LDEQ. March 1997.

Smythe, E. deEtte. 1999. Overview of the 1995 and 1996 Reference Streams. Prepared for Engineering 2 Section, Environmental Technology Division, Louisiana Department of Environmental Quality, Baton Rouge, LA: June 28, 1999.

USGS. 1971. Drainage Area of Louisiana Streams. Basic Records Report No. 6. Prepared by US Geological Survey in cooperation with Louisiana Department of Transportation and Development Baton Rouge, LA: 1971 (Reprinted 1991).

USGS. 1980. Low-Flow Characteristics of Louisiana Streams. Water Resources Technical Report No. 22. Prepared by US Geological Survey in cooperation with Louisiana Department of Transportation and Development, Baton Rouge, LA.

USGS. 1992. Flow Duration and Low-Flow Characteristics of Selected Arkansas Streams. Water Resources Investigations Report 92-4026. Prepared by US Geological Survey in cooperation with Arkansas Soil and Water Conservation Commission, Little Rock, AR.

USGS. 1998. Louisiana GAP Land Use/Land Cover Data. Downloaded from Spatial Data and Metadata Server, National Wetlands Research Center, US Geological Survey. (http://sdms.nwrc.gov/gap/landuse.html).

Wiland, B.L., and K. LeBlanc. 2001. LA-QUAL for Windows User's Manual, Model Version 4.12, Manual Revision E Beta. Wiland Consulting, Inc. and Louisiana Department of Environmental Quality. March 7, 2001.

APPENDIX A THROUGH R ARE AVAILABLE THROUGH EPA UPON REQUEST

APPENDIX S

Responses to Comments

COMMENTS AND RESPONSES
BAYOU DE LOUTRE TMDL FOR DO
May 28, 2002

EPA appreciates all comments concerning this TMDL. Comments that were received are shown below with EPA responses or notes inserted in a different font.

GENERAL COMMENTS FROM LOUISIANA DEPARTMENT OF ENVIRONMENTAL QUALITY (LDEQ):

Note: LDEQ submitted one document containing comments on 98 TMDLs for various pollutants and subsegments throughout the Ouachita and Calcasieu basins. Only the portions of that comment document that apply to the DO and nutrient TMDLs in the Ouachita basin (10 subsegments) are shown below. Some of the general comments may not apply to this report.

The Louisiana Department of Environmental Quality hereby submits comments on the 98 TMDLs and the calculations for these TMDLs prepared by EPA Region 6 for waters listed in the Calcasieu and Ouachita river basins, under section 303(d) of the Clean Water Act. Listed below are general comments.

1. Many of these TMDLs are based on models using historical water quality data gathered at a single or small number of locations rather than survey data gathered at sites spaced throughout the waterbody. The hydraulic information used was generally an average value or estimated value, not taken at the same time as the water quality data. The calibrations are inadequate due to the lack of appropriate hydrologic data and the paucity of water quality data. The resulting TMDLs are invalid. LDEQ does not accept these TMDLs.

Response: The TMDLs were based on existing data plus information that could be obtained with available resources. Each model was developed using the most appropriate hydraulic information and water quality data that were available. A rationale was provided for data use and assumptions and limitations were given. Although LDEQ typically collects more data for model calibration than what was available for calibration of most of these models, EPA considers these model calibrations and the resulting TMDLs to be valid.

2. LDEQ does not consider any of these waters to be impaired due to low dissolved oxygen, nutrients, or ammonia. Many of these waters simply have inappropriate standards and criteria. The resources spent on developing these TMDLs could have been far more effectively and wisely spent on reviewing, approving, and assisting in the development of appropriate standards and criteria for these waters through the UAA process.

Response: TMDLs were developed for these subsegments based on the requirements of Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 and the suspected causes of impairment (organic enrichment/low DO and/or nutrients) for each subsegment in the EPA Modified Court Ordered 303(d) List. TMDLs must be established to meet existing water quality standards. If it is determined that a standards changes is appropriate, the TMDL can be revised to reflect that change.

3. CBODu and NH3-N were estimated from surrogate parameters rather than actual measured data for most of the TMDLs. The TMDL report uses the LDEQ's multi-basin loading database's median ratio values between the ultimate loads and the proposed surrogates. This data was based on the measured data from the last two years of LDEQ water quality surveys. LDEQ objects to the correlation of TOC to CBOD and NH3-N to TKN unless these correlations are taken from water quality data on the modeled waterbody. Our studies have shown only a moderate correlation between these parameters within the same waterbody, however when this correlation was attempted across waterbodies, extreme variability was seen and the correlations were not judged valid. It is possible that a combination of surrogates will obtain a better correlation, such as TOC along with color, turbidity, pH, etc. LDEQ is currently researching these options.

Response: EPA agrees that it would be ideal to have data collected from each modeled waterbody for relating TOC to CBOD and NH3-N to TKN. However, none of these subsegments had sufficient data from which these relationships could be developed. Relationships with surrogate parameters were used only when data for the desired parameter was not available.

4. BOD decay rates were estimated from surrogate parameters rather than actual measured data for most of the TMDLs. The TMDL report uses the LDEQ's multi-basin loading database's median values. This data was based on the measured data from the last two years of LDEQ water quality surveys. It has been LDEQ's experience that these rates vary significantly from waterbody to waterbody and frequently vary significantly within the same waterbody. LDEQ objects to using surrogate data without regard for specific waterbody conditions for these parameters.

Response: Due to the schedule and level of resources available for this project, it was not feasible to perform long term BOD time series analyses on samples from these waterbodies. Given this situation, using LDEQ’s database was considered the best approach for estimating decay rates.

5. A winter projection model was not developed for most of the TMDLs. Winter projection models must be developed to address seasonality requirements of the Clean Water Act. Where point sources have seasonally variable effluent limitations or such seasonal variations are proposed, a winter projection model is required to show that standards are met year-round.

Response: As discussed in Section 4.2 of each report, summer is the most critical season for meeting the year round standard for DO for these subsegments. Therefore, the summer simulation satisfies the seasonality requirements of the Clean Water Act. The available information for point source discharges indicated that the facilities discharging to these waterbodies do not have seasonal permit limits. If any of these facilities wishes to pursue seasonal permit limits, then LDEQ or the permittee can re-run the model to develop seasonal wasteload allocations.

6. LDEQ takes exception to the calculation of a TMDL based on TN/TP ratios derived from waterbodies other than the modeled waterbody. It is LDEQ's experience that the natural allowable TN/TP ratio is waterbody-specific and can vary dramatically between streams.

Response: These nutrient TMDLs were developed using naturally occurring ratios of nitrogen to phosphorus based on Louisiana’s narrative water quality standard for nutrients. These ratios were calculated using reference stream data rather than long term monitoring data for each subsegment because the reference stream data were considered to be more appropriate for naturally occurring conditions.

7. LDEQ has not adopted the EPA recommended ammonia criteria (1999) and takes exception to its use in these TMDLs. In general, LDEQ does not accept EPA's use of national guidance for TMDL endpoints. The nationally recommended criteria do not consider regional or site- specific conditions or species and may be inappropriately over protective or under protective. No ammonia nitrogen toxicity has been demonstrated or documented in any of the waterbodies in these TMDLs. The general criteria (in particular, LAC 33:IX.1113.B.5) require state waters be free from the effects of toxic substances.

Response: Ammonia toxicity calculations were performed to ensure that the ammonia loadings that will maintain DO standards will not cause any exceedences of the ammonia toxicity criteria. National guidance for ammonia toxicity was used in the absence of any numerical state water quality standards for ammonia. EPA believes that this evaluation offers assurances that waters will continue to be free from the effects of toxic substances.

8. Algae were not simulated. Was there evidence that algae did not have an impact on the waterbody? Did the contractor have any Chlorophyll a measurements on which to base this determination?

Response: For most of these subsegments, the effects of algae were not simulated in the models because there were no data to clearly demonstrate a need for including algae and the models calibrated well without including algae (i.e., the models were calibrated without having to use unreasonable coefficients to compensate for algal effects).

SPECIFIC COMMENTS FROM LDEQ FOR BAYOU DE LOUTRE:

1. The Fortran program used by the contractor does not adequately show the methodology used in determining the percent reduction based on the projection loading. From the information that is given, LDEQ believes that the chosen method is contrary to the current method in use by the Department.

Response: The percent reductions were calculated by subtracting the projection input value from the calibration input value and then dividing by the calibration input value. This procedure is slightly different than what LDEQ uses but still provides percent reductions that are useful considering the uncertainty in reductions that can be achieved with any specific BMP. These calculations were actually done outside of the Fortran program; the program was just used to calculate the TMDL components (i.e., the numbers in Table 5.1).